Asthma and the New York City Environment

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Introduction

The incidence of asthma is increasing rapidly in our nation, and at an even faster rate in urban areas. The goal of this research project is to find out what role our environment plays in the triggering of an asthma attack. This study is unique in that it realizes that both indoor and outdoor air qualities and in, meteorological variables are all factors when it comes to asthma.

Asthma is defined as "a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role...in susceptible individuals, the inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing."(Bethesda 1997) It is of great concern to our community to find the answer to why asthma rates are increasing so rapidly. "Asthma is the most common chronic disease of childhood in the developed world, affecting approximately ten million children in the United States under 16 years of age" (Clarke 1999). The question of, "is our environment changing," is what is asked to try and justify the increase in asthma rates.

Over the past few decades, the division of the United States government that monitors the air quality, Environmental Protection Agency, issued various regulations on six criteria pollutants, in the document named the Clean Air Act. Since the time of its enactment in the 1970s, industry in the United States has made the honest effort to reduce their pollution output by installing machines such as scrubbers to clean out their smoke stacks. The result was a cleaner atmosphere for Americans, as the larger, more

visible, particles such as particulate matter 10, have been reduced; however there has been nothing so far to reduce the output of smaller particles, particulate matter 2.5. These smaller particles have been associated in aggravating asthma attacks. Therefore a study into all the various components that can affect the concentration and distribution of particulate matter, such as precipitation, wind speed, and the various precursors to the formation of that particle, needed to be done. Understanding these relationships will enable a better understanding of why there has been a doubling of the rates of asthmatics in our nation in the past decade. This study examines the immediate environment of New York City inhabitants to find if there is a relationship with these various factors asthma.

One of the factors that possibly have an affect on asthma incidence are the daily concentrations of ambient air pollutants. Pollutants can be classified in two groups, gases and aerosols. Aerosols are small liquid or solid particles suspended in the air. Aerosols are emitted into the air or formed as a result of chemical reactions in the air. Examples of toxic gases are ozone (O_3), nitrogen oxides (NO_x), and sulfur oxides (SO_x), which are precursors to the formation of aerosols, nitrates and sulfates. These particles, namely nitrates, are very small in diameter, and therefore will be able to penetrate deeper into the respiratory tract. In various studies, it has been shown that there is a relationship between the nitration fraction of particulate matter and mortality due to asthma.

"Particulate matter is the generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. Particles originate from a variety of stationary and mobile sources. They may be emitted directly or formed in the atmosphere by transformation of gaseous emissions such as sulfur oxides (SO_x), nitrogen oxides (NO_x), and volatile organic substances" (EPA). The Environmental Protection Agency (EPA) devised new standards for both particulate matter and ozone in 1997. They raised the standards of particulate matter from ten microns in diameter (PM 10) to 2.5 microns in diameter (PM 2.5). Particulates included in the PM 10 range (2.5 microns to 10 microns), are usually produced by natural methods, such as wind blown dust from the desert or an agricultural field. This type of particulate matter does not have as severe affects

as PM 2.5 that can penetrate deeper into the respiratory track, potentially triggering an asthma attack. Particulate 2.5 consists of particulates 2.5 microns in diameter or less. These particles are formed when sulfur oxides and nitrogen oxides (from fossil fuel combustion) react with water producing sulfates and nitrates (aerosols). The difference between PM 10 and PM 2.5 is not only the size of the particle, but since they come from different sources, they have a different chemical properties.

A time span of one year, 1997 was selected in which comparisons of the hospitalization due to asthma will be correlated with both ambient air quality variables and that of the local weather. Ambient air quality variables are the concentrations of particulate matter 10 (PM 10), particulate matter 2.5 (PM 2.5), and nitrogen dioxide. The meteorological variables that is focused on in this study is wind speed and precipitation. The wind speed and its affective direction will have an affect on the distribution of aerosols from their source depending upon the speed. Though this study does not elucidate what triggers asthma, relationships between levels of atmospheric pollutants and/or meteorological variables can be used provide asthma alerts.

Methods

Ambient air quality data for New York City was obtained from the Environmental Protection Agency (EPA). Where in hourly measurements of nitrogen dioxide (NO_2) was taken at EPA monitoring sites at various sites within New York City. Using an Instrumental Pulsed Fluorescent apparatus, calculations of mean concentrations for the day were made, in addition to mean and maximum concentrations for the hour. The unit of measurement is parts per million (ppm) within the volume. The minimum concentration that can be measured is 0.002 ppm. The format of data set is in hourly samples, the max and mean for each hour are taken in addition to the mean for the day. Calculations of mean concentrations for the day are made, in addition to mean and maximum concentrations for each hour. The max and mean for the hour was graphed to see the time at which each gas peaks.

Particulate matter concentrations are measured at different time intervals in comparison to the gaseous pollutants mentioned above. As opposed to hourly measurements, particulate matter is measured

every sixth day. Particulate matter is collected in a fourteen-meter apparatus that samples the ambient air quality. The units of measurement are in micro-grams per cubic meter ($\mu g/m^3$); i.e., a density. A limitation of this instrument is that the PM concentration has to exceed 4 $\mu g/m^3$ in order to be measurable. Particulate matter 2.5 was a new standard that started in 1997 by the EPA. Thus, a year's worth of data began in 1997. This is a limitation to this research project in that particulate matter 10 can not be used as a proxy for particulate matter 2.5, as they are from different sources. Particulate matter 10 has been implicated in causing increased respiratory problems and increased mortality, as PM 10 encompasses PM 2.5, however a stronger relationship has been found for PM 2.5.

Weather also affects the concentrations and distribution of different aerosols and gases in the atmosphere. Daily weather data for 1997 was obtained from the Weather Underground (http://www.wunderground.com). There are two ways in which aerosols are taken out of the atmosphere. Either they fall out, due to their weight as they continue to react with compounds in the atmosphere, or they are washed out by precipitation, rain, snow. Wind speed and direction affects the distribution and concentration of aerosols as when there is a little wind, there can be a build up of pollution. This is because wind carries aerosols from place to place. Wind direction was not looked into, but can for the future, as it may give an indication of the source of the aerosol.

Mount Sinai School of Medicine provided daily asthma hospitalization data for two zip codes within the Bronx and two within Brooklyn. The time series of daily asthma hospitalization is compared with the EPA ambient air quality data and meteorological data. Dates in which there were high hospitalizations will be compared to corresponding dates for the different gases, aerosols and meteorological variables to see if a relationship exists.

Results

In such a project, where the constant we are looking at, which are asthma hospitalizations, not just increase over time, but have different rates across the city. Therefore, the probable cause to this difference and increase over time may be due to a factor in the environment that is also experiencing the

same change. First we look at particulate matter 10 to see if any particular borough had a significantly higher concentration from the others. Some might predict that the Bronx will have the highest concentration, however, the five boroughs have, to a certain magnitude, the same level of particulate matter. This is because particulate matter encompasses stratospheric aerosols, such as wind blown dust, which is pretty constant for certain, latitude. The correlation between monitoring sites for PM 10 ranged from .85 to .97.

Daily hospitalizations for the Bronx were compared to corresponding ambient air quality and weather data. Seasonal trends of these different variables were looked at to find a relationship between these variables and asthma. Ambient air quality and weather variables are compared on a daily scale to examine seasonal trends. These seasonal trends may help us have a better understanding of the seasonal cycles of asthma frequencies (high in winter). The seasonal trend of NO2 and PM 10 were the same, as the two functions had a .716 correlation, both peaking in the summer time. However, asthma peaks in the fall, and is lowest in the summer there was only a -.06 correlation between the monthly, seasonal cycle of PM 10 and asthma hospitalizations in the Bronx. Nitrogen dioxide gave a similar result, of a correlation of -.1.

The data is divided in percentage of days with hospitalizations due to asthma, and without hospitalizations due to asthma. The NO_2 data was sorted like the weather data based on percentage of days with hospitalization and without hospitalization. The same was done for Particulate matter 10. Wen one looks at the seasonal trends of both particulate matter10 and NO2, it does not have a positive correlation with asthma, as NO2 and PM 10 peak in the summer, the time in which asthma is at its lowest incidence. Therefore the days in which there was above average concentrations of these pollutants was analyzed. When this was done, it seemed to show a relationship between NO2 and hospitalization, but not PM 10. Next, I looked at pollution events in 1997 to see what affect it has on hospitalization, if any. Remarkably, asthma hospitalization cases increased from just 44 percent of days to 62.5 percent of days.

Meteorological variables were also sorted by percent of days. This brought about an interesting result. As shown through the EPA data, PM 10 and NO2 concentrations decrease when there is precipitation. Therefore, we will expect there also to be a decrease in hospitalizations when it rains or snows, because the air is getting cleaner. However, the percent of days in which there was hospitalizations, 44.7 per cent did not have any precipitation, and 47.4% had perception. Therefore, we will hypothesize that another significant factor that will prone an asthma attack is an indoor air pollutant.

Discussion

As one looks into the reasons why asthma is increasing at the rate it is, one has to look at factors that are also increasing or changing. That is why nitrogen dioxide can be considered a possible factor in this increase. Previous research conduced at NASA GISS ICP showed a trend between asthma mortality and the nitrate fraction of particulate matter. Emissions in particulate matter, ozone, and sulfur dioxide has all decreased, yet, asthma is increasing. Nitrogen dioxide is the only one that has increased. Nitrogen oxide, may have a better relationship with asthma, as it does have a seasonal cycle, peaking in the winter, which my survey and the asthma data from Mount Sinai also suggest. Though the seasonal cycle of PM 10 does not match that of asthma, particulate matter 10 can not be discarded as a possible contributor to an increase in asthma incidence, as it encompasses everything less than ten microns in diameter, and that includes PM 2.5. As stated earlier, particulate matter 10 has been shown to have an affect on respiratory diseases, however particulate matter 2.5 has been shown to have a better relationship. in the future, the same procedure needs to be taken with PM 2.5 to see if pollution episodes has the same, or more sever affects on asthma hospitalizations. In addition, its seasonal cycle needs to be compared with that of hospitalizations as PM 10 and PM 2.5 do not come from the same sources and therefore may have different seasonal trends. With the increase in measurements PM 2.5, a better relationship and prediction can be made of asthma incidences. Though companies are using more filters to reduce their emissions, these filters get the large particles, but not the small ones. Particulate matter 2.5 can travel deep within the respiratory system.

Further studies must be done into the indoor air quality of our homes, schools and work place. It was shown that during pollution events, there is an increase in asthma hospitalizations. And in addition, precipitation was shown to decrease the concentration of pollutants in the atmosphere. Therefore it would be logical that asthma rates will also decrease due to precipitation. However, on days in which it rains or snows, many are indoors, therefore that may be a significant contribution to that increase in asthma rates. Further study into meteorological variables, such as precipitation and wind direction needs to be done, as it will affect the concentration and distribution of these particles that have been associated with probing an asthma attack.

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